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POLICY PERSPECTIVE

Enhancing the Value and Validity of EIA: Serious Science to Protect Australia's Great Barrier Reef

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Abstract

The unique values of Australia's Great Barrier Reef (GBR) are under threat from environmental change and the unforeseen, cumulative consequences of coastal development. Development decisions are underpinned by Environmental Impact Assessments (EIAs) but these are plagued by inconsistent methods and a lack of independent evaluation, leading to perceptions of inadequate scientific rigor. To be credible and effective, EIAs should be subject to independent peer review, the yardstick applied in the normal process of science. Without it, decisions based on EIA are at best contestable and potentially invalid. Peer review should be applied to the whole EIA process from project development to reporting and auditing approval requirements. It should be based on rigorous, standard protocols, and produce standardized and publicly available data. Securing the future of the GBR and other global natural assets requires refocusing EIA so it becomes a tool for strategic environmental protection rather than ad hoc permitting of development.

Introduction

The Great Barrier Reef World Heritage Area (GBRWHA) is not just a jewel in Australia's National Estate but an outstanding part of the world's natural heritage; it is the world's most extensive coral-reef ecosystem and one of the few biological features visible from space. Inscribed on the World Heritage List in 1981, it fulfils criteria vii-x for World Heritage inclusion (UNESCO 2015) based on superlative natural beauty, intactness, ecological significance, unique geomorphological features and natural habitats. However, a long succession of contested development decisions has led to a series of negative environmental outcomes for the GBRWHA estate (Grech *et al.* 2013), all of which were unstated or understated in Environmental Impact Assessments (EIAs). The accumulation of these developments, an example of the tyranny of small decisions, now threatens the unique environmental and cultural values of the GBRWHA, and puts at risk the $5.7 billion economic value of the Great Barrier Reef (GBR) (Deloitte Access Economics 2013) to the Australian economy.

The recently completed marine and coastal strategic assessments of the GBR highlight many of the factors contributing to declines in its ecosystems and species (DSDIP 2013). Some, such as tropical cyclones, are unpredictable; others are large-scale factors like climate change that are outside the control of local regulators. However, another class of factors relate to the negative consequences of decisions about coastal planning and industrial development throughout the GBR catchment, covering some 424,000 km^2 or 23% of the state of Queensland. Approximately 10% of the GBR's 2,300 km coastline is already affected by coastal development and industrial expansion (Waltham & Sheaves 2015), with the cumulative impact of many small and large developments

resulting in extensive habitat modification or loss, and in the exclusion of biota dependenxt on coastal ecosystems from extensive tracts of critical habitat (Sheaves *et al.* 2014).

At the centre of most major development decisions are Environmental Impact Statements (EISs) based on EIAs. Although EIAs are "scientific" studies, they have been plagued by both perceived and functional problems since their first introduction. At the most fundamental level EIA is a "... procedure for evaluating the likely impact of a proposed activity on the environment" (UNECE 1991); a procedure developed to balance three societal influences: (i) environmental concerns, (ii) the need for more objective decision-making; and (iii) greater public involvement in decision-making (Weston 2004). However, there is a common perception that EIAs are of dubious validity; serving the interests of proponents of development rather than their ostensible purpose of assessing the status and vulnerability of ecosystems (Cashmore 2004). Consequently, the EIA process is often viewed as simply a bureaucratic step in obtaining development approval (Brown & Hill 1995), driven by big business and political pressure (Beanlands & Duinker 1983) with an emphasis on appearance over substance; with being seen to conduct an EIA more important than meeting the in-principle requirements of the science (Cashmore 2004).

Whether or not these concerns are well-founded, there are functional weaknesses in EIA processes. Potential conflict of interest is intrinsic to most EIAs because the EIA operator or consultant is invariably selected by the development proponent (Brown & Hill 1995), or because the proponent is also the regulator (Grech *et al.* 2013). Moreover, what can be achieved in an EIA is limited by time and budgetary constraints (Morrison-Saunders & Bailey 2003), and the specific terms of reference (ToRs) (Grech *et al.* 2013), adding to the appearance of scientific incompleteness. These weaknesses are reinforced by inconsistencies in some EIAs, such as the selective inclusion of information and incomplete coverage of assumptions and caveats (Fairweather 1994), leading to an impression of tokenism and questionable ethics, and to the possibility that the proposed development is cast in the most favorable light possible rather than evaluated independently and scientifically (Fairweather 1994).

Problems

While EIA in essence evaluates "... the likely impact of a proposed activity on the environment" (UNECE 1991), in practice it is usually seen by regulators as "... the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made" (IAIA 2009). Considered closely, these two definitions represent contrasting views of EIA's role. The first highlights environmental protection, while the second emphasizes enablement of development (Brown & Hill 1995).

The question for any particular development is: Which of these interpretations is most relevant? Undoubtedly, development is important and inevitable, but just as clearly there are cases where the environmental asset is so valuable that protection should be paramount. In the case of protecting natural assets of international significance, such as the GBR, it is critical to minimize the chance of failing to detect the potential for damage to the asset (i.e., Type II error) (Legg & Nagy 2006), making rigorous scientific assessment of the likely impacts, and the evaluation of the effects of cumulative impacts, of paramount importance. This is all the more important given the undeniable record of environmental decline in the GBR resulting from the cumulative effects of catchment land uses, coastal developments, and climate change (De'ath *et al.* 2012).

In this situation, strong procedures aimed at minimizing the chance of Type II error—failing to act to protect the environment when action is warranted—are required. This emphasis is needed even at the expense of Type I error—taking action when none is warranted, or unnecessarily preventing development (Type I error). Type I error results only in additional management intervention, representing a financial cost to the proponents of the development but no cost to the environmental asset (Legg & Nagy 2006). The cost of Type II error in the GBR is local and perhaps wider adverse impacts, adding to the already large cumulative impact of development across the region (Grech *et al.* 2013).

The GBR is managed under the Great Barrier Reef Marine Park Act 1975, with the stated main objective of providing for "... the long term protection and conservation of the environment, biodiversity and heritage values of the Great Barrier Reef Region" (GBRMPA 1975). In accordance with the Act, EISs are mandatory for "complex or large scale" projects. However, the requirements for review of the EISs, and the EIAs that underpin them, are not stipulated. Although guidelines generally include a statement such as "A copy of all data and the sampling methodologies must be made available for the purpose of peer review on receipt of a written request ..." (SEWPaC/GBRMPA 2011), there is no obligation for independent peer review. When an EIS is approved for public release, in-house experts from relevant government agencies, consultants engaged by government agencies, and the public can make submissions, although time-frames can be as short as a few weeks. However,

this process does not pass the test of independent review. Independent peer review is a documented, critical review performed by one or more persons with technical expertise in the subject matter and independent of the work being reviewed (Council 1997). The lack of independent peer review of Australian EIAs is pervasive, extending from a lack of review of initial tender submissions and proposals to a lack of review of draft reports and recommendations (Fairweather 1994).

Although the EIA process used in Australia seems comprehensive, it has proven ineffective at preventing either environmental degradation of the GBR or controversy (see Supplementary Information 1). A number of factors contribute to this (Table 1). The process of individual proponent-driven EIAs leads to many independent studies resulting in an immense volume of assessments that lack consistency of standards or methods. For instance, since 1993, there have been at least 28 impact assessments relating to a single component of the Hay Point port development (see Supplementary Information 2), and over 600 reports and data sets related to the controversial Gladstone Port development (Llewellyn *et al.* 2013). Such developments thereby generate a voluminous "gray" literature, with limited distribution making them difficult to obtain, and short time-frames available for review limiting scrutiny by the scientific community. The process of selecting EIA operators by each development proponent for each new project introduces the potential for a lack of independence, and the likelihood of undetected cumulative impacts. It also creates the potential for inconsistency, because even when standard methods are employed, the use of different survey operators can lead to conflicting results (Kearney 2002). This result is a mass of individual data sets that differ in methods of collection and sampling design, and suffer from inconsistent taxonomic identification (Hutchings *et al.* 2007). These inconsistencies greatly reduce the opportunities to integrate data sets, and limit the potential for synergistic advantages that accrue from cross-study integration and the ability to consider spatial differences and temporal changes (Beanlands & Duinker 1983). The problem is compounded by many data sets being considered commercial-in-confidence, making them generally unavailable. The lack of integration also has substantial costs for the proponents; they cannot take advantage of the cost savings that would result from accessing integrated, consistent data sets, so must often commission new studies that repeat work already done. Moreover, unlike the situation in other jurisdictions, there is no central data repository for GBR data from EIAs that would enable information from previous surveys to be accessed to inform new studies.

The timing of assessment is often inappropriate (Brown & Hill 1995). The most useful input to a development proposal comes at the design stage (Bos *et al.* 2014), facilitating the identification of existing data to help assess temporal change, as well as allowing modifications to improve designs and methods. Moreover, assessment at the end of the EIA process is often too late to influence project planning because irreversible decisions (such as land acquisitions) have been made and funding committed (Brown & Hill 1995), emphasizing the token nature of some assessments.

Perhaps most important is the issue of scientific validity. The legitimacy of EIA depends on its systematic, scientific basis (Weston 2004) but, as early as 1994, it was recognized that the standard of science in Australia's EISs was far below that found in published journals (Fairweather 1994). This perception of poor rigor persists (Kämpf & Clarke 2013). The lack of standard, transparent, rigorous, and independent peer review of project designs, results, and conclusions inevitably lays the foundations for skepticism because the conclusions of EIA have not been evaluated using the yardstick applied in the normal process of science (Beanlands & Duinker 1983; Fairweather 1994). As a consequence, decisions based on studies lacking independent peer review are at best contestable and potentially invalid. Review by "relevant government departments" does little to dispel the doubts because of public suspicions that government departments have inherent conflicts-of-interest (DiMento & Ingram 2005). For instance, "review by government departments" raises a clear question of conflict-of-interest in the case of the controversial Gladstone Port that is owned by a Queensland Government entity, the Gladstone Ports Corporation.

Solutions

While development decisions will remain contentious, because views among the Australian public span the spectrum from pro- to anti-development, it is possible to substantially strengthen the validity of the EIA studies that underpin decisions, limiting the need to re-do studies, providing greater surety of quality outputs, greater transparency, minimizing the risk of Type II error, and generally increasing confidence in resulting decisions. Most of the actual and perceived problems with EIA can be addressed by instituting comprehensive, independent peer review (DiMento & Ingram 2005) that goes beyond assessment of the final product by extending also to influence the direction, design, rigor, and consistency of the whole EIA process. This coordinated approach would have the added advantage of increasing the breadth and

Table 1 Summary of some major problems stemming from current EIA practice in the Great Barrier Reef World Heritage Area and its catchment

Problem	Explanation
Process-focused	EIA is largely focused on required process rather than on substantive outcomes for the environment
Voluminous assessments	EISs are voluminous, unwieldy documents that are difficult for the public, and even experts, to evaluate
Proponents select EIA operators	Provides the potential for conflict-of-interest and lack of coordination among studies
The proponents can also be the regulator in the case of the Queensland Government	Further scope for conflict of interest
Short review periods	Short periods of time available for review of large documents
Poor integration	Proposal-by-proposal commissioning of EIAs produces many independent assessments that are poorly integrated
Commercial-in-confidence data	The data from many EIAs are commercial-in-confidence or unavailable. Consequently, the synergies that would be available from meta-compilation of huge data sets are not possible. There is also a major cost impost, with each new study potentially redoing existing data collections
Lack of consistent, transparent, and independent oversight	There is rarely rigorous, transparent, and independent review of the project design, results, or conclusions. Consequently, many studies are of doubtful value because their scientific validity is untested
A lack of coordination among studies and no standard set of methods	A lack of consistent standards for sampling methods, sampling design, replication, analysis, or reporting, leading to inconsistent data, outputs, and interpretations. In addition, a lack of consistent oversight means there is usually little consistency in the way data are collected, the level of replication, or the spatial and temporal resolution of coverage. In effect, even studies focusing on the same biological or physical component are likely to be measuring different variables in different ways
Lack of a centralized database with free access	The lack of even a centralized compilation of metadata means there is no way of knowing what data exist, and no information on the details of those data. This reinforces the difficulty of developing synergies among studies
Differing ToRs	Most EIAs have had tightly constrained terms of reference (ToRs), restricting the scope of the work conducted and the conclusions made, and limiting compatibility with other studies and thereby the utility of the data for meta-compilation
A lack of consistent accreditation of consultants	There is no standard accreditation of operators who conduct EIAs. Lack of surety of operator competence undermines credibility and compatibility
Fragmented development of expertise	The operators conducting EIAs change from project to project, meaning that the opportunity is missed for development of detailed expertise in key areas (e.g., identification of benthic infauna). This severely limits the ability for consistent identification of fauna and often restricts identification to high (imprecise) taxonomic levels, reducing the ability to identify change due to developments and leaving many, possibly unique, species unidentified
EIA conducted in relation to project logistics not scientific necessity	Timing, duration, and scope of EIAs are usually determined by logistical and budgetary considerations, so often fail to consider the spatio-temporal requirements of scientifically valid assessments

usefulness of data available, leading to the ability to detect cumulative and large-scale impacts, optimizing the value of monitoring and enabling adaptive management-type learning.

If the substantive purpose of EIA is to ensure minimum damage to natural assets of national and international importance, effective consideration of likely environmental impacts needs to conform to the norms of scientific research. These norms are: a basis in fact (Beanlands & Duinker 1983), valid sampling and statistical design aimed to produce unequivocal results (Underwood 1990), unbiased and comprehensive reference to published research (Fairweather 1994), and a clear understanding of uncertainty and risk (Harris & Heathwaite 2012). Comprehensive, independent peer review is a logical requirement for ensuring alignment of EIA with scientific understanding, and ensuring that scientific understanding takes precedence over short-term benefits and political considerations—ensuring EIA serves public, not private, interests (Fairweather 1994).

As well as ensuring the EIA process is transparent (Brownlie 2005), and that uncertainty is recognized and addressed early in the project cycle (Beanlands & Duinker 1983), independent peer review is important for mitigating risk where uncertainty, and therefore the potential for controversy, is high. For instance, a well-accepted, well-understood, and transparent process that acknowledges and incorporates uncertainty is important in deciding the acceptability of a proposal under the precautionary principle (Harris & Heathwaite 2012).

What might a comprehensive, independent peer-review process look like?

To be as effective as possible, while handling the large volume of environmental assessments generated within the GBR, an independent peer-review process would need to be centrally organized and funded. Similar processes have proved effective in Canada and the Netherlands, where EIAs are controlled by independent EIA commissions.

A likely model for the GBR is a proponent-funded (e.g., Bos *et al.* 2014) peer-review process governed by an independent expert panel that directs assessments to expert peer reviewers in the field (Figure 1). To be most effective, peer review should include the initial advice statement (including ToR), a statement of acceptable risks from the project, EIA design, and the draft final report. Evaluation of the EIA design is critical (Bos *et al.* 2014) to ensure EIA studies are as well directed as possible and to allow the development of an acceptable project plan before money is spent or commitments made (Brown & Hill 1995).

For maximum effectiveness and cross-study integration there needs to be a set of standard protocols and guidelines (Beanlands & Duinker 1983) that take due regard of issues such as statistical power (Legg & Nagy 2006), and the use of standard study and sampling methods. The standard protocols then become the criteria against which the EIA design is judged. To ensure consistent quality, all operators contracting for impact assessment studies should be accredited through a certification process overseen by the independent expert panel.

The use of standard methods would make extensive data integration feasible. Consequently, there should be mandatory, full public access to data. Currently a large body of data is claimed as commercial-in-confidence with little justification. For instance, there seems no reason why all biological data relating to the GBR should not be publicly available, because the public, including researchers, has an interest in the organisms and habitats investigated that may be at least as great as that of development proponents (Costanza *et al.* 2006). Scientific research programs funding under the Australian Research Council are required to make all collected data available; this same level of transparency should also apply to EIA.

Integrated information management systems are the key to synthesized outcomes (Ayles *et al.* 2004), and the ability to access a large body of data can provide substantial benefits in increased effectiveness and relevance, and provides the opportunity to put an EIA into broad spatio-temporal context essential for understanding cumulative outcomes (Ayles *et al.* 2004). To make full use of publicly available data and ensure their availability for public scrutiny, a managed data repository should be funded by development proponents. Making data publicly available need not be expensive. For instance, the repository could be linked to the Open Science movement (http://www.openscience.org/). The benefits of integrating data and making them available via a data management system have already been demonstrated in one area of the GBRWHA, with the mass of literature produced over the last 40 years of intense development of Gladstone Harbour assembled in a data repository to provide historical benchmarks for monitoring (Llewellyn *et al.* 2013).

Would peer review work?

Comprehensive, independent peer review is recognized as vital in related areas; a key component of well-managed monitoring programs (Legg & Nagy 2006) and central to the success of environmental offsets programs (Bos *et al.* 2014). Peer review has a history of successful application to the GBR, with Great Barrier Reef Marine Park Authority's use of external referees in the 1980s–1990s leading to substantially higher-quality monitoring than seen elsewhere in Australia (Warnken & Buckley 2000).

Peer review is also supported by many EIA practitioners who see it as a positive step towards improving project design, methods, the quality of information, and reporting (Morrison-Saunders & Bailey 2003). Some practitioners also see a strong peer-review process as helping free them from reconciling the extent of work they believe needs doing with the constraints of limited budgets and time-lines. Under peer review, time and budgets would need to fit scientific necessity rather than arbitrary constraints.

Managing the cost

The comprehensive process of peer review outlined in Figure 1 might be seen as prohibitively expensive. But is this true? Such a model would be more expensive than the current EIA process, but should that be an impediment to the protection of a natural asset of international significance? If independent peer review of EIAs contributed to halting the continual degradation of the GBR and helped safeguard it for future generations, that in itself would seem to justify the extra expense. However, there are likely to be more tangible economic benefits. In contrast to the current fragmented approach to EIA, with different proponents commissioning studies that often repeat previous work, the ability to freely access the results of previous studies and confidently utilize them would reduce the need for new studies, provide larger, more valid data sets for assessment and decision-making, and lead to substantial savings. There is also the

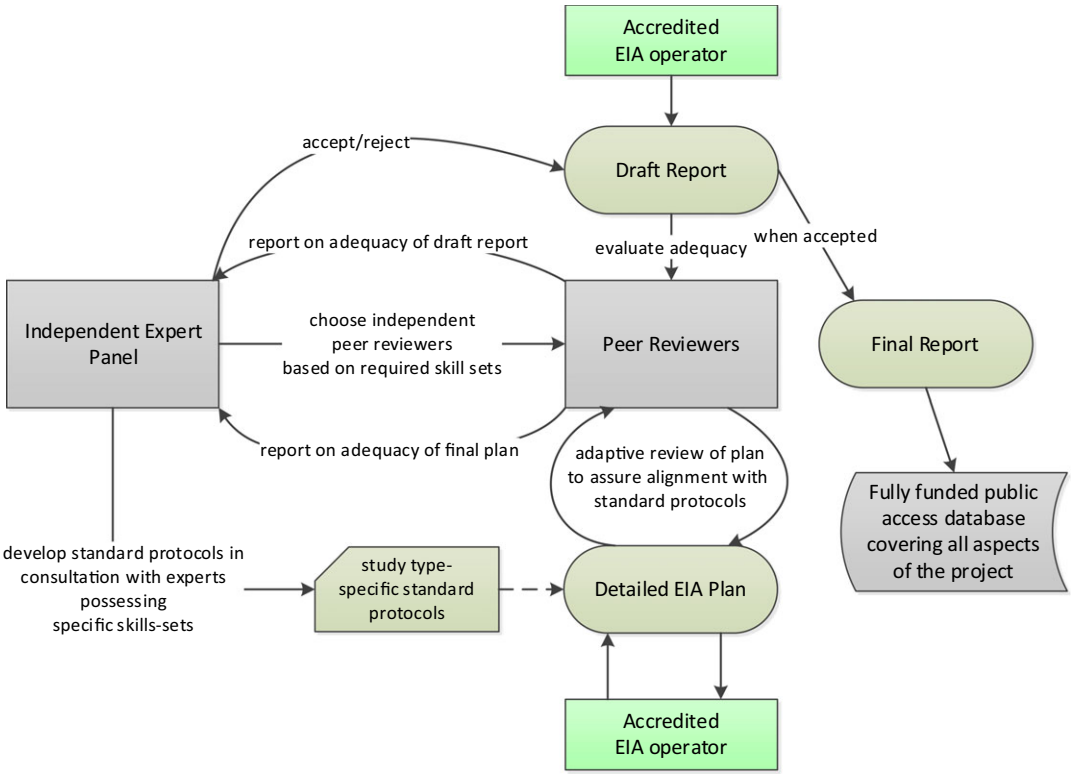

Figure 1 Framework for a comprehensive, independent peer-review process.

benefit to governments and proponents that a more transparent process, with results presented in a readily understood way, would increase public acceptability of the results. Additionally, getting assessments right in the first instance would limit the need for proponents or the Australian public to fund costly remediation exercises, as has often been the case in the past (Grech *et al.* 2013).

Conclusion

The condition and resilience of the GBRWHA—*and other global natural assets*—justify the most strenuous efforts to ensure that long-term preservation overrides the pragmatism of short-term financial accounting. Decisions about development of the GBR coast and hinterland need to be based on serious science. In the case of environmental assessment, that means subjecting EIAs to the same rigorous standards demanded of other applications of science—applying the yardstick of scientific quality afforded by independent peer review. Independent peer review might appear difficult and problematic for regulators to deploy, but precedents indicate its feasibility. More importantly, without peer-reviewed EIA, the GBRWHA is likely condemned to a continuing cycle of unsatisfactory outcomes and controversy, while environmental degradation continues.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Supplementary Information 1. Examples of documented instances of major problems stemming from current Environmental Impact Assessment practice in the Great Barrier Reef World Heritage Area and its catchment.

Supplementary Information 2. List of reports for Hay Point port development activities.

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